Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

EXPERIMENTAL APPLICATION OF THE PHOTO-TOPOGRAPHICAL METHOD OF SURVEYING TO THE BAIRD GLACIER, ALASKA.

It is believed that the method of photographic surveying, as developed by Mr. E. Deville, surveyor general, Dominion of Canada, will prove of great assistance to those engaged in the study of the motion of glaciers. The method is briefly described by the writer in the annual report for 1894 of the Association of Ontario Land Surveyors.

While engaged at other work in connection with the Canada-Alaska boundary survey, — Mr. W. F. King, H. M. Commissioner, — during the past season (1894) I embraced the opportunity of taking a number of views of the Baird Glacier, Thomas Bay, from the same stations and at different times for the purpose of studying its motion near its termination. The stations occupied were three in number, all situated on the fluvio-glacial plain which extends for upwards of half a mile between the glacier and the sea. The bases used were 865 and 2065 feet in length, and were measured with a tape, and their azimuth determined with a transit from solar observation. Mountain peaks and other fixed points within the photographic field were also read upon, for the purpose of orienting the views. Two crossed rings were painted on the rock bordering the east side of the moraine and tied to the triangulation for future reference, should any one again take observations or measurements of the glacier. The work done is but a small part of what might or should be done for a complete study of the motion of the glacier in all its parts. This was beyond my sphere and the time available. However, the little that was accomplished will show satisfactorily the applicability of the camera for the study of glacial motion, and also give some facts regarding the motion of the Baird Glacier.

It may be interesting to state how I proceeded to arrive at the results hereafter given, and to point out the difficulties encountered.

From views taken from the 865-foot base,—about 1700 feet from the glacier, which has a frontage of a mile—I plotted that part of the glacier that was intervisible; this gave me some thirty points on the glacier-front whose distance and height became known, and thereby the general contour and slope; the latter was found to be 1:3. This, of course, is far in excess of the slope of the glacial stream proper, which is found from our surveys to extend (the western branch) over fifteen miles in in a straight line into the interior and to have a slope of 1:20. It may be mentioned that this branch and the Dawes Glacier emptying into Endicott Arm have the same névé. The mean slope of the Patterson Glacier, lying southeast of the Baird, is in ten miles, 1:13.

The difficulty in using a long base for photographing the face of the glacier is that it is then pretty difficult to recognize many points common to both stations. The photographs were taken on May 15, 19, July 13 and August 11, 1894. The nearest base station (No. 3) was about 900 feet from the ice. The photographs taken from this station show most markedly the change and motion that took place between July 13 and August 11,—twenty-nine days—on which dates views were taken too from station No. 1, 2065 feet from the former. Some fifteen points on the glacier were distinctly recognizable from both stations, and hence plotted in distance and altitude. We had now a fairly accurate delineation of a part of the glacial front so that the distance to any point therein became well enough known to utilize for the purpose to be shortly explained.

It is evident that from photographs from the same station but at different times changes are best seen. A photograph itself, however, only furnishes the angular measurement of any point thereon, both in azimuth and altitude, but not linear measure. Hence, when we are comparing photographs of the same views from the same station, we must know the distances—or approximately at least—to points under consideration for interpreting properly the changes as shown by the photographs. The glacier having been plotted as already stated, any required distance was obtainable.

A question that suggested itself from the photographs was that of determining the shrinkage or melting of the ice (ablation) between July 13 and August 11, irrespective of any motion. This was obtained in the following manner: On the photographs well-marked points were selected on the adjacent mountains, verticals through which cut the glacier. Each point selected was common to both views. Evidently points which lie in the same vertical plane in one photograph lie in the same plane in another photograph from the same station. There were thus eighteen intersections common to two photographs of the crest of the face of the glacier obtained. We hence had the angular measurement of these intersections, and as the distances thereto were sufficiently well known, the linear measure followed. It is not forgotten that, especially near the face of the glacier, the motion of the ice causes crevasses and upheavals so that in a particular vertical section there may be an abnornal decrease or increase in elevation and the phenomenon of shrinkage obliterated or at least hidden. In fact, the observations or photographs show such to be the case; for in one instance we have a rise of nearly six feet, instead of a decrease of two feet as the average shows. From these eighteen intersections we find that during the twenty-nine days,—July 13 to August 11,—the mass of the glacier—ice front—fell a little over two feet (2.1 feet).

Let us now examine the linear motion of the ice. This problem we can attack from two points—using only photographs from one (nearest—No. 3) station.—Firstly, by finding the vertical motion, and secondly by determining the change in azimuth. The former is directly obtained by measuring on the photographs the distance of a point on the two photographs, above the horizon line, then from its known distance the absolute height in each case is obtained, and the difference will be the motion in altitude for the interval of the photographs. From the general plotting of the glacier we have its average slope, which in this case is 1:3. From points treated in this way we obtain a mean fall for any particular point during the twenty-nine days of 11.2 feet, being equivalent to a motion of 33.6 feet.

For comparing the azimuths of the same point in two photographs we refer the point in each to the same vertical through some point on the mountains—(the verticals drawn for the purpose of ascertaining the shrinkage were utilized). The linear measure taken on the photographs combined with the fixed focal length of the camera gives the desired angular differences in azimuth, and this latter applied to the known distance of the point gives the motion of the point at right angles to its direction from the station. The quantity expressive of the above motion must be corrected for the actual direction of the point. This latter direction we again obtain from our general plot of the glacier whereon the direction of ridges is established.

For eighteen points change of azimuth was thus determined, and from the relative position of the station to the glacier front the change in the absolute azimuth of a point changed from minus to plus, those to the left or west decreasing, those to the right or east increasing in azimuth, while those directly in front, *i. e.*, where the direction from the station to the point was coincident with the line of motion, showed no change in azimuth. From these we obtain a mean absolute motion of 29 feet, which, combined with the above, gives a mean motion of a fraction over a foot per day from July 13 to August 11. From this data alone it would be imprudent to give an estimate of the total motion in the year. The greatest distance of any point considered was about 3000 feet from the station.

The results obtained may be summarized:

Between July 13 and August 11, 1894, the end of the Baird Glacier was lowered by melting a little over two feet, and the average motion of the ice in that part was one foot per day.

The Baird Glacier consists of two arms, each about 16 miles long. About one and three-quarters miles from the terminal moraine they merge into one stream. At the western side emerges a subglacial torrential river, carrying an enormous amount of ground and disintegrated rock—mud. It looks almost too thick to flow. In consequence of its eroding action and the pressure of the moving glacier, its vaulted ice roof near the ice front from time to time collapses, and large masses of ice are then carried out to sea by the rushing waters. Water is found issuing from other parts of the glacier, and not only from underneath but at various points on its face, but only in small streams, and is generally clear or has the characteristic milky color. Although the greater part of the face of the glacier looks "dirty," yet but very few stones are imbedded therein. There is a large quantity of débris on the surface of the glacier, brought down many miles from the eastern arm. The débris is composed of material varying from fine gravel to large bowlders.

An interesting feature of the photographs obtained is the morainic ridge that borders almost continuously the ice front. Its height is about five feet. Examining the photographs of July 13 and August 11, taken from the same station, it is seen that the mounds of which the ridge is composed have changed. This change, like the mounds themselves, is not due to addition of detritus from the face of the glacier, otherwise the accumulation of matter would lie in contact with the ice, which is not the case. The formation of the ridge, and consequently any change thereof, is due to the motion of the toe of the glacier. A side-view photograph taken just beside the glacier makes this apparent.

When we approach the glacier within one or two hundred yards, we meet with depressions in the fluvio-glacial deposit, which increase in depth and sharpness of outline as we advance. The depressions or holes have a maximum depth of about five feet and diameter of about fifteen feet. In a few of the deeper ones a pool of clear water was found. The cause of these depressions is not very apparent. They have not been excavated by streams, but to explain them by the melting of parts of the glacier which projects for some distance underneath the terminal deposit, though plausible, is yet not quite satisfactory.

It would take up too much space to describe in detail our methods of photographic surveying, but a few hints may be suggested to those unfamiliar with the subject and whose explorations and scientific inquiries afford an opportunity for gathering valuable data in the field by means of the camera, which may be subsequently worked out. The first requisite is the utilization of a constant (the principal) focal length for all photographs taken. This necessitates a rigid camera box with no focus adjusting arrangement (bellows). The lens should be a good one, giving a flat image and having an angle of about 60°. To give sharpness to distant points an orange glass screen is always screwed to the front of the lens. This, of course, increases the time of exposure. In the center of each side of the box and in front of the plate is fixed a brass point or comb each of which shows on every photograph and together they serve to orient the photographs. The camera must always be horizontal, to insure which a small level is placed on top; preferably one composed of two in the form of a T. It is convenient to have a foot for the camera so that it can be placed and leveled on the tripod of the transit or theodolite necessary for making the skeleton triangulation, to which the photographs are referred. For good work glass plates are essential. They should be orthochromatic. A convenient size for transport is 4¾ by 6½ inches. In panoramic views, adjoining photographs should have at least one well-recognizable point in common, *i. e.*, the photographs should overlap.

In applying the camera to the study of the motion of glaciers, it is difficult to give definite instructions what to do, as the conditions presented vary so widely. Each case will suggest the most advantageous course to pursue; what length of base to measure; how many pickets to plants across a glacier (it is well to distinguish the pickets by having alternate ones with a "cross-head" T), etc. The photographs want to be taken from the stations, and at intervals of time of a week or weeks, or months, dependent upon the conditions and thoroughness of investigation required. In general we may say that the same considerations obtain in the selection of photo-topographic stations as for trigonometric stations, *i. e.*, that the intersections for the location of points may be of fairly well conditioned triangles. Every photograph gives — knowing the focal length of the lens — the angular measurement of every point on the photograph, *i. e.*, the azimuth of any point from any other point, and also the angular elevation or depression above or below the horizon of the camera. OTTO J. KLOTZ.

DEPARTMENT OF THE INTERIOR.
Ottawa, Canada.